Chapter 1.0 Introduction

1.1 WHAT INFORMATION IS PRESENTED IN THIS REPORT?

This report presents the United States (U.S.) Environmental Protection Agency's (EPA) latest estimates of national emissions for criteria air pollutants: carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOCs [excludes certain nonreactive organic compounds]), sulfur dioxide (SO_2), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), and lead (Pb). Although not a criteria pollutant, emission estimates for ammonia (NH_3), a compound that plays an important role in the secondary formation of particles, are also presented. The Clean Air Act (CAA) requires that the EPA Administrator publish a list of pollutants that have adverse effects on public health or welfare, and are emitted from numerous and diverse stationary or mobile sources. For each pollutant, the Administrator must compile and publish a "criteria" document. The criteria documents are scientific compendia of the studies documenting adverse effects of specific pollutants at various concentrations in the ambient air. For each pollutant, National Ambient Air Quality Standards (NAAQS) are set at levels that, based on the criteria, protect the public health and the public welfare from any known or anticipated adverse effects. These regulated pollutants are therefore called "criteria pollutants." We describe some of the health effects in section 1.2.

Summaries of ambient air quality measurements collected by federal, State, and local agencies, and the status of compliance with the NAAQS, can be found in the series of annual air quality trends reports, the most recent of which is the *National Air Quality and Emissions Trends Report, 1998* (EPA-454/R-00-003).

Graphs of national emission estimates, beginning in 1900 for NO_x, VOC, and SO_2, aggregated by major source category, are presented in Chapter 3. We provide more detail for these pollutants, and CO and PM_{10} beginning with 1940. Information related to $PM_{2.5}$ and NH_3 starts with 1990, the first year EPA developed estimates for these pollutants. We include additional detail for the current year. This report also contains information on estimation methods that we have updated during the past year. Revised international emissions from Europe and Canada, air toxic emissions, greenhouse gas emissions, and biogenic emissions are also presented.

1.2 WHAT ARE THE HEALTH AND ENVIRONMENTAL EFFECTS OF CRITERIA POLLUTANTS?

CO enters the bloodstream and reduces the delivery of oxygen to the body's organs and tissues. The health threat from CO is most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. It affects healthy individuals also but only at higher concentration levels. Exposure to elevated CO levels is associated with impairment of visual perception, work capacity, manual dexterity, learning ability and performance of complex tasks.[1] Prolonged exposure to high levels can lead to death.

Nitric oxide (NO) is the principal oxide of nitrogen produced in combustion processes; it is readily oxidized in the atmosphere to nitrogen dioxide (NO_2). Collectively, NO and NO_2 are referred to as NO_x. NO_2 can irritate the lungs and lower resistance to respiratory infection (such as influenza). Nitrogen oxides are an important precursor both to ozone (O_3) and to acidic deposition and may affect both terrestrial and aquatic ecosystems. Atmospheric deposition of nitrogen (nitrate, NO_x, other compounds derived from NO_x) leads to excess nutrient enrichment problems (eutrophication); prominent examples are: Chesapeake Bay and several other nationally important estuaries along the East and Gulf Coasts.[2] Eutrophication can produce multiple adverse effects on water quality and the aquatic environment, including increased nuisance and toxic algal blooms, excessive phytoplankton growth, low or no dissolved oxygen in bottom waters, and reduced sunlight causing losses in submerged aquatic vegetation critical for healthy estuarine ecosystems. Nitrogen oxides are a precursor to the formation of nitrate particulate matter (PM) in the atmosphere; this effect is most important in western areas.[3] NO_2 and airborne nitrate also contribute to pollutant haze, which impairs visibility and can reduce residential property values and revenues from tourism.

VOCs are a principal component in the chemical and physical atmospheric reactions that form O_3 and other photochemical oxidants. The reactivity of O_3 causes health problems because it damages biological tissues and cells. O_3 is also responsible each year for agricultural crop yield loss in the United States of several billion dollars and causes noticeable foliar damage in many crops and species of trees.

Forest and ecosystem studies show that damage is resulting from current ambient O_3 levels plus excess nutrient enrichment and, in certain high-elevation areas, acidification.[3]

SO_2 is a precursor to the formation of sulfate PM, including acid and nonacid aerosols, in the atmosphere. Sulfate aerosols make up the largest single component of fine particulate matter in most locations in the eastern United States.[4] The major health effects of concern associated with exposures to high concentrations of SO_2, sulfate aerosols, and PM, include effects on breathing, respiratory illness and symptoms, alterations in the lung's defenses, aggravation of existing respiratory and cardiovascular disease, and mortality. Children and the elderly may be particularly sensitive. Also, SO_2 can produce foliar damage on trees and agricultural crops.

Together NO_x and SO_2 are the major precursors to acidic deposition (acid rain), which is associated with several environmental and human health effects. These effects include acidification of lakes and streams, impacts on forest soils, accelerated corrosion of buildings and monuments, and visibility impairment plus respiratory effects on humans associated with fine sulfate and nitrate particles.

Based on studies of human populations exposed to ambient particle pollution (sometimes in the presence of SO_2), and laboratory studies of animals and humans, the major effects of concern for human health include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis, and premature mortality. Particulate matter causes damage to materials and soiling; it is a major cause of substantial visibility impairment in many parts of the United States.[4]

Fine particles ($PM_{2.5}$) are of health concern because they easily reach the deepest recesses of the lungs. Batteries of scientific studies have linked fine particles (alone or in combination with other air pollutants), with a series of significant health problems, including:

- Premature death
- Respiratory related hospital admissions and emergency room visits
- Aggravated asthma
- Acute respiratory symptoms, including aggravated coughing and difficult or painful breathing
- Chronic bronchitis
- Decreased lung function that can be experienced as shortness of breath
- Work and school absences[5]

Exposure to Pb can occur through multiple pathways, including inhalation of air, diet and ingestion of Pb in food, water, soil, or dust. Pb accumulates in the body in blood, bone, and soft tissue. Because it is not readily excreted, Pb also affects the kidneys, liver, nervous system, and blood-forming organs. Excessive exposure to Pb may cause neurological impairments such as seizures, mental retardation and/or behavioral disorders. Even at low doses, Pb exposure is associated with changes in fundamental enzymatic, energy transfer and homeostatic mechanisms in the body. Fetuses, infants, and children are especially susceptible to low doses of Pb, often suffering central nervous system damage. Recent studies have also shown that Pb may be a factor in high blood pressure and subsequent heart disease in middle-aged Caucasian males.[6]

NH_3, in the presence of water in the atmosphere reacts with sulfates and nitrates to create ammonium sulfate and ammonium nitrate, both of which are particles. Particles formed via chemical reactions in the atmosphere are known as secondarily formed particles and play an important role in the overall $PM_{2.5}$ particle budget.

1.3 WHAT ENHANCEMENTS HAVE BEEN MADE TO THE REPORT?

Since 1973, EPA has prepared estimates of annual national emissions in order to assess historic trends in criteria pollutant emissions. While these estimates were prepared using consistent methodologies and were useful for evaluating emission changes from year to year, they did not provide an absolute indication of emissions for any given year. Beginning with the 1993 Emission Trends Report (containing data through 1992), EPA established a goal of preparing emission trends that would also incorporate the best available annual estimates of emissions.[a]

The EPA's Emission Factor and Inventory Group (EFIG) has developed procedures and criteria for replacing *Trends* data with emissions data submitted by States as part of a variety of ongoing programs (such as O_3 State Implementation Plan [SIP] submitted data). This report contains data obtained from several States through the 1996 periodic emission inventory (PEI) data submittals. Information related to how these data were incorporated into the National Emission Trends (NET) data base is given in Chapter 5.

The EFIG is also developing a data management and reporting system for emissions data. When the system is complete, the EFIG can extract the most current State inventories of emissions and supplement the gaps with EPA-generated attainment area emission inventories. The EFIG has already made several changes to the *Trends* methodology to make the transition smoother.

In this report, there are five distinct time periods: 1900 to 1939, 1940 to 1984, 1985 to 1989, 1990 to 1996, and 1996 forward. Since the accuracy and availability of historical data is limited, we have not generally made revisions to estimates before 1984 (with some exceptions, discussed in Chapter 5).

However, many changes in current year totals have been incorporated into the reported estimates using State data.

Please note that methodologies within a given time period (especially more recent periods) will also vary, as we include more accurate data in the ***Trends*** *data base.*

Although there are many changes to the *Trends* methodology, some aspects have remained constant. For example, the 1900 through 1939 NO_x, VOC, and SO_2 estimates are extracted from the National Acid Precipitation Assessment Program (NAPAP) historical emissions report.[7,8] In addition, Pb estimates (1970 to present), and all CO, NO_x, VOC, SO_2, and PM_{10} estimates from 1940 to 1984 reported in *Trends* are based upon the previous national "top-down" methodology. Continuous emission monitoring (CEM) data reported by electric utilities to the Acid Rain Program's Emission Tracking System (ETS) were used, whenever available and complete, for NO_x, SO_2, and heat input values for the years 1996 and 1997. (These data apply to steam generated fossil-fuel units with nameplate capacity of at least 25 megawatts [MW].) These are some of the most accurate data collected by EPA because they represent actual monitored, instead of estimated, emissions.[5]

As has been stated in the past several Emission Trends Reports, EPA plans to incorporate as much State-derived data as possible into the Trends estimates. This report reflects the use of State data, specifically those data submitted by various States as part of the 1996 PEI reporting effort.

When data were not available, were deemed inappropriate for use in presenting emission Trends, or when EPA felt that we had a more robust mechanism for estimating emissions from a particular source sector, EPA relied on nationally derived estimates. We describe changes made to estimation techniques for this year in Chapter 5 of this report. Methods used for other source categories that we did not change for this year's report are detailed in the National Air Pollutant Emission Trends, Procedures Document, 1900-1996.[9] In general we updated the 1996 inventory with State data and then projected estimates for 1997 and 1998 based on economic or other types of growth indicators (such as the State Energy Data System (SEDS) fuel consumption estimates) to develop estimates for 1997 and 1998. We also applied reductions resulting from the Clean Air Act Amendments of 1990 (CAAA) to the 1997 and 1998 estimates. Throughout the report we have indicated when the changes in emissions are due mainly to methodological changes.

We have made two other significant enhancements to the report. First, the discussions of emission estimates and emission trends are oriented around types of sources rather than around pollutants. EPA has found that in questions related to emissions and emission trends, most requesters want information related to how much of a pollutant is emitted by a particular source, rather than the total emissions of a pollutant no matter the source. While there are still sections that discuss overall emissions by pollutant, there are larger sections of the report that we have oriented around the following five categories:

- combustion;
- industrial;
- on-road;
- non-road; and
- miscellaneous.

In particular, these five broader categories are used to provide additional clarity for information presented graphically. When these broader categories are used, they represent emissions from the following Tier categories (see section 1.4 and Table 1-1 for Tier category descriptions):

Category	Tier 1 Categories Included
Combustion	1, 2 and 3
Industrial	4, 5, 6, 7, 8, 9, and 10
On-road	11
Non-road	12
Miscellaneous	13 and 14

Some figures also show an "all other" category. The all other category represents the sum of all other Tier category emissions that are not specifically shown in the figure.

The second major change in the document is the usage of "plain language." In June 1998, President Clinton issued a memorandum instructing all government agencies to use plain language in new documents developed after October 1, 1998. Plain language is designed to produce documents that have logical organization, easy-to-read design features, and use common, everyday words (except necessary technical terms), "you" and other pronouns, the active voice (where possible), and short sentences (where possible). More information about the plain language initiative can be found at:

http://www.plainlanguage.gov/

1.4 HOW IS THE REPORT STRUCTURED?

Changes made in the format of the October 1995[10] report, intended to make the report more comprehensible and informative, within the framework of the plain language initiative, are maintained for this report. The executive

summary presents a brief overview of each chapter of the report. In this introduction, Chapter 1, we inform the reader of changes to the report, the health effects of criteria air pollutants, and the structure of the report. A detailed account of the current year emissions by pollutant, source category, State, nonattainment area (NAA), county, and season and by a listing of top-emitting facilities is given in Chapter 2. National trends in emissions from 1900 (where available) to the current year and demographic, economic, and regulatory influences on emission trends are discussed in Chapter 3. Information on SO_2 emissions from industrial sources is presented in Chapter 4. An explanation of new methods of estimating pollutant emissions started during the past year is found in Chapter 5. Biogenic NO_x and VOC emissions are presented in Chapter 6. Emissions from sources, noncriteria pollutants, or countries not traditionally part of the *Trends* report are displayed in Chapters 7, 8, and 9. The EPA and other governmental agencies developed these emissions. In each chapter, numeric superscripts represent references and alphabetic superscripts represent endnotes.

As in last year's report, all emissions reported in tables and figures in the body of the report are in units of thousand short tons, except Pb.[b] The pollutants are presented in the order of CO, NO_x, VOC, SO_2, PM_{10}, $PM_{2.5}$, Pb, and NH_3 throughout this report. We developed emissions at the county and Source Classification Code (SCC) level for the years 1985 to 1998 for most source categories. We then summed these emissions to the national Tier level. There are four levels in the tier categorization. The first and second level, respectively called Tier 1 and Tier 2, are the same for each of the six criteria pollutants. [NOTE: Tier 2 in this context should not be confused with the recently announced Tier II motor vehicle control standards] The third level, Tier 3, is unique for each pollutant. The fourth level, Tier 4, is the SCC level. The match-up between SCC and all three tier levels can be obtained by contacting EFIG (see Note at the bottom of Table 1-1). Table 1-1 lists the Tier 1 and Tier 2 categories used in Chapters 1 through 5 to present the criteria air pollutant emission estimates. Tables and figures appear at the end of each chapter in the order in which we have discussed them within the chapter. Appendix A contains tables listing emissions for each of the criteria pollutants by Tier 3 source categories. If emissions are reported as zero, the emissions are less than 0.5 thousand tons (or 0.5 tons for Pb). "NA" indicates that the apportionment of the historic emissions to these subcategories is not possible. If a tier category does not appear, then emissions are not currently estimated for that category (either EPA estimates the emissions as zero or does not currently estimate the emissions due to time or resource limitations).

Throughout this report, emission estimates of PM_{10} and $PM_{2.5}$ are presented by source category as total from all sources, including fugitive dust sources, and nonfugitive dust sources. Fugitive dust sources are included in the following tier categories.

Tier 1	Tier 1 Name	Tier 2	Tier 2 Name
13	Natural Sources	02	Geogenic (wind erosion)
14	Miscellaneous	01	Agriculture and Forestry (agricultural crops or tilling and feedlots)
		07	Fugitive Dust (paved and unpaved roads; unpaved airstrips; construction; mining and quarrying; wind erosion - industrial; point source - haul roads)

Emissions of NO_x are expressed as weight-equivalent NO_2. Thus, we have inflated the actual tons of NO emitted to report them as if they were NO_2. You should therefore assume that the molecular weight was that of NO_2 when using numbers in this report.[c]

We report the VOC emissions as the actual weight of many different compounds. The relative amounts of the individual compounds emitted will determine the average molecular weight of a given source category's emissions. Therefore, no equivalent molecular weight standard exists for VOC. The VOC emissions referred to in this report exclude those organic compounds considered negligibly photochemically reactive, according to the EPA definition of VOC in the Code of Federal Regulations (40CFR51.100).[11] Thus, we have not included methane, ethane, and certain other organic compounds in the VOC totals.

1.5 REFERENCES

1. "Air Quality Criteria for Carbon Monoxide," EPA/600/8-90/045F (NTIS PB93-167492), Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1991.
2. "Air Quality Criteria for Oxides of Nitrogen," EPA/600/8-91/049aF-cF.3v, Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1993.
3. "Air Quality Criteria for Ozone and Other Photochemical Oxidants," Volume I of III, EPA/600/8-93/004aF, Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1996.
4. "Air Quality Criteria for Particulate Matter and Sulfur Oxides," EPA/600/8-82/029aF-cF.3v (NTIS PB84-156777). Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1991.
5. "Health and Environmental Effects of Particulate Matter," Fact Sheet, Office of Air and Radiation, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. July 17, 1997.
6. "Air Quality Criteria for Lead," EPA/600/8-83/028aF-dF.4v (NTIS PB87-142378), Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1991.
7. "Historic Emissions of Sulfur and Nitrogen Oxides in the United States from 1900 to 1980," EPA-600/7-85-009a and b, U.S. Environmental Protection Agency, Research Triangle Park, NC. April 1985.
8. "Historic Emissions of Volatile Organic Compounds in the United States from 1900 to 1985," EPA-600/7-88-008a, U.S. Environmental Protection Agency, Research Triangle Park, NC. May 1988.
9. "National Air Pollutant Emission Trends Procedures Document, 1900-1996," EPA-454/R-98-008, U.S. Environmental Protection Agency. May 1998.
10. "National Air Pollutant Emissions Trends, 1900-1994," EPA-454/R-95-011, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1995.
11. *Code of Federal Regulations*, Title 40, Volume 2, Parts 50 and 51 (40CFR51.100), pages 131-136, U.S. Government Printing Office. Revised July 1, 1999.

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a. The great majority of all emission data necessarily are estimates. Exhaustive, on-site quantification, source by source, is a practical, and an economic, impossibility.

b. Lead emissions are measured in short tons. Short tons can be converted to metric tons by dividing the emissions by a factor of 1.1023.

c. The term nitrogen oxides (NO_x) encompasses emissions of both nitrogen dioxide (NO_2) and nitric oxide (NO).

Table 1-1. Major Source Categories

Tier 1 CODE*	Tier 1 NAME	Tier 2 CODE	Tier 2 NAME
01	***FUEL COMBUSTION-ELECTRIC UTILITIES***		
		01	Coal
		02	Oil
		03	Gas
		04	Other External Combustion
		05	Internal Combustion
02	***FUEL COMBUSTION-INDUSTRIAL***		
		01	Coal
		02	Oil
		03	Gas
		04	Other External Combustion
		05	Internal Combustion
03	***FUEL COMBUSTION-OTHER***		
		01	Commercial / Institutional Coal
		02	Commercial / Institutional Oil
		03	Commercial / Institutional Gas
		04	Misc. Fuel Combustion (except residential)
		05	Residential Wood
		06	Residential Other
04	***CHEMICAL & ALLIED PRODUCT MFG.***		
		01	Organic Chemical Mfg.
		02	Inorganic Chemical Mfg.
		03	Polymer & Resin Mfg.
		04	Agricultural Chemical Mfg.
		05	Paint, Varnish, Lacquer, Enamel Mfg.
		06	Pharmaceutical Mfg.
		07	Other Chemical Mfg.
05	***METALS PROCESSING***		
		01	Nonferrous
		02	Ferrous
		03	Metals Processing (not elsewhere classified [NEC])
06	***PETROLEUM & RELATED INDUSTRIES***		
		01	Oil & Gas Production
		02	Petroleum Refineries & Related Industries
		03	Asphalt Manufacturing
07	***OTHER INDUSTRIAL PROCESSES***		
		01	Agriculture, Food, & Kindred Products
		02	Textiles, Leather, & Apparel Products
		03	Wood, Pulp & Paper, & Publishing Products
		04	Rubber & Miscellaneous Plastic Products
		05	Mineral Products
		06	Machinery Products
		07	Electronic Equipment
		08	Transportation Equipment
		09	Construction
		10	Miscellaneous Industrial Processes
08	***SOLVENT UTILIZATION***		
		01	Degreasing
		02	Graphic Arts
		03	Dry Cleaning
		04	Surface Coating
		05	Other Industrial
		06	Nonindustrial
		07	Solvent Utilization (NEC)
09	***STORAGE & TRANSPORT***		
		01	Bulk Terminals & Plants
		02	Petroleum & Petroleum Product Storage
		03	Petroleum & Petroleum Product Transport
		04	Service Stations: Stage I
		05	Service Stations: Stage II
		06	Service Stations: Breathing & Emptying
		07	Organic Chemical Storage
		08	Organic Chemical Transport
		09	Inorganic Chemical Storage
		10	Inorganic Chemical Transport
		11	Bulk Materials Storage
		12	Bulk Materials Transport
10	***WASTE DISPOSAL & RECYCLING***		
		01	Incineration
		02	Open Burning
		03	Publicly Owned Treatment Works
		04	Industrial Waste Water
		05	Treatment Storage and Disposal Facility
		06	Landfills
		07	Other
11	***ON-ROAD VEHICLES***		
		01	Light-Duty Gasoline Vehicles & Motorcycles
		02	Light-Duty Gasoline Trucks
		03	Heavy-Duty Gasoline Vehicles
		04	Diesels
12	***NON-ROAD ENGINES AND VESSELS***		
		01	Non-road Gasoline Engines
		02	Non-road Diesel Engines
		03	Aircraft
		04	Marine Vessels
		05	Railroads
13	***NATURAL SOURCES***		
		01	Biogenic
		02	Geogenic (wind erosion)
		03	Miscellaneous (lightning/freshwater/saltwater)
14	***MISCELLANEOUS***		
		01	Agriculture & Forestry
		02	Other Combustion (wildfires)
		03	Catastrophic / Accidental Releases
		04	Repair Shops
		05	Health Services
		06	Cooling Towers
		07	Fugitive Dust

Note(s): * Code numbers are presented for The Representative Emissions National Data System (TRENDS) user.
The Source Classification Code (SCC) definitions and assignment to Tier category are available on the Technology Transfer Network's (919-541-5742) Emission Inventories/Emission Factors Information (CHIEF) Technical Information Area, or on the Internet (**www.epa.gov/ttn/chief**).